PLATHINIUM
PLASMA THIN FILM INTERNATIONAL UNION MEETING
13-17 September 2021
Antibes, French Riviera
WWW.PLATHINIUM.COM
100% VIRTUAL

Electrical diagnostics for Dielectric Barrier Discharges: from integrated measurements to spatially resolved measurements. Benefits for plasma processes at atmospheric pressure?

Clémence Tyl, Antoine Belinger, Simon Dap, Nicolas Naudé

LAPLACE, Université de Toulouse, CNRS, INPT, UPS, 31062 Toulouse, France

Dielectric Barrier Discharges (DBDs) can be used in many processes as thin-film coating, sterilization, treatment of gases, aerodynamic flow control, and lighting devices [1]. Depending on the gas, electrical operation parameters and discharge geometry, the plasma operates in the classical filamentary mode or in a homogeneous regime [2]. Electrical measurements are a more convenient than optical measurements to characterize the discharge regime and to study the discharge behavior. However, and because of the dielectric presence, it is not possible to directly measure the electrical parameters of the discharge. Usually, the electrical parameters are calculated from the measured quantities under usage of an electrical equivalent circuit [4]. The key parameter for this approach is the determination of the discharge area, which is usually considered to be equal to the electrode surface as long as the discharge is homogeneous. However, even if the plasma seems to cover the electrodes uniformly, its electrical properties (current density, breakdown voltage, duration of discharge, …) are not exactly the same at any time and at any point of the surface. For example, when a gas flow is injected from one side of the planar DBD arrangement, tthe species densities are not the same along the gas flow because of the kinetic processes and chemical reactions in the discharge [4]. Thus, the discharge current and the gas voltage are not uniform along the spatial DBD dimensions. Therefore, determination of discharge current and gas voltage from macroscopic parameters of the DBD is often inacurrate.

In order to have a more accurate characterization of the discharge behavior, a measurement of the local current density is required. To get a 2D mapping of the discharge electrical parameters, the ground electrode is prepared as a segmented electrode with 64 equally spaced square segments. The high voltage electrode still remained full. This electrode is a 3x3 cm^2 square, while each square of the segmented electrode has a 3.44 mm side length, a distance of 350 µm spaced each segments. A prototype, using a ground electrode divided into 64 identical squares and a data acquisition system has been developed [5]. This system can be used to study the spatial electrical behavior of a DBD. It has been successfully validated on planar DBD by the comparison with short exposure time photos taken by a camera from above the discharge cell [5]. It has been used to study the diffuse discharge (APTD) and shows the effect of a gas flow on the local electrical behavior of the discharge. In the case of diffuse DBDs with sinusoidal voltages at frequencies from 1 to 20 kHz, the temporal and spatial resolutions are high enough to characterize the behavior of the discharge with sufficient spatial information.

This electrode arrangement and measuring systems allows a 2D mapping of the discharge electrical parameters (discharge current, power dissipated, gas voltage, etc.) of Townsend but also for Glow discharges, hybrid or patterned regimes. Concerning the plasma processes for surface coatings, this system can be used to monitor the evolution of the local discharge power which defines the local deposition rate. If we use this segmented electrode as the high voltage electrode with adequate power supply, we could reconfigure the electrode and the power transfer to the discharge. Then this system could be used to realized patterns. All of this opens up new directions which will be discussed during the presentation.

References:

1. U. Kogelschatz, Plasma Chem Plasma P 23 (1), 1-46 (2003).
2. R. Brandenburg, Plasma Sources Science and Technology 26 (5), 053001 (2017).
3. A. V. Pipa, J. Koskulics, R. Brandenburg and T. Hoder, Rev Sci Instrum 83 (11), 115112 (2012).
4. C. Tyl, X. Lin, M. C. Bouzidi, S. Dap, H. Caquineau, P. Segur, N. Gherardi and N. Naudé, J Phys D Appl Phys 51 (35) (2018).
5. C. Tyl, S. Martin, C. Combettes, G. Brillat, V. Bley, A. Belinger, S. Dap, R. Brandenburg, N. Naudé, Rev Sci Instrum 92 (5), 053552 (2021).